

Controlled angle viewing screens by interference techniques

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Abstract

A hardened gelatin film on a transparent substrate forms a rear projection viewing screen providing high efficiency and uniformity of illumination with predetermined scattering characteristics over a relatively wide field of view. This is accomplished by the presence within the gelatin film of a scattering pattern corresponding to a certain three-dimensional interference pattern recorded therein. This certain interference pattern results from the exposure of the gelatin film, after light sensitization thereof, with substantially coherent light which has passed through a diffusing medium having a given cross sectional area which is spaced a given distance from the film, followed by the development of the exposed film by a process which includes rapid drying of the film after immersion thereof.

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(54) MANUFACTURE OF REAR PROJECTION SCREENS

(71) We, RCA CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is directed to a viewing screen capable of providing relative uniformity of illumination over a given, e.g. relatively wide field of view and to a method for making such a screen.

In rear projection systems such as slide viewers and microfilm readers, an image is generally projected onto a diffusing screen where it is presented to the observer. Such a rear projection screen is generally viewed near the axis of the system. The diffusing screen should scatter the largest possible fraction of the light towards the observer, i.e., have a high efficiency, thereby requiring a smaller quantity of illumination. The screen should scatter the light not only with high efficiency, but also in such a manner that the intensity of the light reaching the observer from various points on the screen is as uniform as possible, i.e., have predetermined scattering characteristics. Conventional screens, e.g., ground glass, do not scatter the light in this desired manner. Conventional screens may have the further disadvantage of allowing a hot spot (i.e., a spot or area which is more intensely illuminated than other areas) to appear near the center of the screen. Such a hot spot causes difficulty to the observer. It therefore is desirable to make a screen capable of overcoming such disadvantages of the prior art.

The invention used to form a rear projection viewing screen results in a screen which has more predetermined scattering characteristics such that the screen is capable of providing relatively uniform illumination over a

given field of view about the normal to the screen.

According to the present invention there is provided a method of forming a rear projection viewing screen which provides in use substantial uniformity of illumination over a given field of view about the normal to the screen comprising: a) preparing a hardened gelatin film on a transparent substrate; then b) sensitizing the gelatin film to substantially coherent light; then c) exposing the gelatin film to substantially coherent light with has been transmitted through a diffusing medium; then d) developing said gelatin film to form therein a three-dimensional interference pattern composed of areas of different refractive index.

Thus the invention provides a method where a hardened gelatin film is prepared on a substrate and then sensitized to light. The gelatin film is then exposed to substantially coherent light. The film thereafter is developed to form a refractive index three-dimensional pattern. According to the invention, the substantially coherent light is transmitted to the sensitized film through a diffusing medium.

In the detailed description of the invention which follows, reference is made to the accompanying drawing. The drawing is an illustration of one form of exposure geometry capable of forming a viewing screen with predetermined scattering characteristics through the method of the present invention.

The exposure geometry, designated generally as 10, includes a source 12 of substantially coherent light, e.g., a He—Cd laser, and a diffusing medium 14 of a material having desired scattering characteristics, e.g., ground glass able to scatter in all directions. A lens 13 can be provided to focus collimate or distribute the light on the diffusing medium 14. A hardened sensitized gelatin film 16, such as a dichromated gelatin, including ammonium, potassium and sodium

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dichromated gelatin, is affixed to one surface of a transparent substrate 18, e.g., glass, plastic, etc. We prefer that ammonium dichromated gelatin be utilized as the film 16, as ammonium dichromate is a well known and easily available photosensitive material. The substrate 18 is positioned wherein the light from the light source 12 first passes through the diffusing medium 14 and then falls incident upon the gelatin film 16 as shown in the drawing.

In a specific embodiment of the present invention, a hardened gelatin film 16 is first prepared on the substrate 18 with a thickness preferably in the range of 6 to 20 microns. The gelatin film 16 can be prepared on the substrate 18 through the method described by H. Lin in App. Optics 8, 963 (1969), in an article entitled "Hologram Formation in Hardened Dichromated Gelatin Films", although other available methods would be equally successful. According to the method of Lin, a 7% (by weight) solution of gelatin, such as USP powdered gelatin, commercially available from J. T. Baker Corporation, is poured over a glass plate, and the excess solution is permitted to run off the plate. After the film is dry, it is hardened by soaking in a photographic fixer containing a hardener for approximately 3 to 5 minutes, followed by washing in water. By varying the concentration of the gelatin solution and the use of multiple coatings, a film thickness in the range of approximately 1 to 20 microns can be obtained. The hardened gelatin film 16 is then sensitized to light, e.g., soaked in a solution of the dichromate, e.g., ammonium dichromate, as described by Lin in the previously mentioned article.

The hardened, sensitized gelatin film 16 is now ready to be exposed. Exposure can successfully occur as shown in the drawing wherein the substantially coherent light emitting from the light source 12 falls upon the diffusing medium 14. The light from the light source 12 passes through the diffusing medium 14 and then falls upon the sensitized gelatin film 16.

It is believed that a further small, localized, hardening occurs in portions of the hardened gelatin film 16 due to increased crosslinking as a result of changes in the state of the chromate ion, as the photons are absorbed. The gelatin film 16 is spaced a distance d from the diffusing medium 14. The diffusing medium 14 includes an area, having a linear dimension W of illumination due to the light emitted from the light source 12. The linear dimension W of illumination on the diffusing medium 14 subtends a maximum angle α at the center point on the hardened, sensitized gelatin film 16. From the exposure geometry of the drawing, it is

therefore apparent that the angle α is a function of the distance d and the linear dimension W . The diffusing medium 14 and the hardened, sensitized gelatin film 16 are positioned wherein the relation of the linear dimension W to the distance d is such that the angle α is preferably in the range of 15 to 40 degrees, for instance 20 degrees producing a viewing screen having particularly favorable scattering characteristics. The magnitude of the linear dimension W can be varied by employing shutters 20 to permit the light from the light source 12 to reach only a selected portion of the diffusing medium 14 while the distance d is varied by moving either the diffusing medium 14 or the gelatin film 16.

The exposed gelatin film 16 is then developed. The exposed film 16 is first washed in water, dehydrated in isopropyl alcohol, removed from the isopropyl alcohol, and then dried for about 30 minutes in an atmosphere of about 60% relative humidity, followed by further drying at 30 to 40% relative humidity or at elevated temperatures, e.g., 100°C, whereupon the exposure becomes permanent. It is believed that washing in water causes the exposed gelatin layer to expand and that the rapid drying rips apart the gelatin, thereby producing minute cracks where the gelatin layer was not exposed. The drying can be performed with greater reproducibility if the developed film 16 is pulled very slowly from the isopropyl alcohol with a stream of hot air simultaneously directed at the film 16 near the alcohol interface.

The light incident upon the diffusing medium 14 need not be collimated, but may be somewhat diverging from a point source. The incident light must be coherent to such an extent that all the light impinging on a given point on gelatin film 16 has a fixed phase relationship. The coherency requirement depends on the directionality of the diffusing medium 14 and the distance d . The distance d can be made as small as desired, even to the point where the diffusing medium 14 contacts the gelatin film 16 whereon the coherency requirement is no serious restriction. Exposure can be made with the He-Cd laser or with various available high pressure mercury arc lamps as the light source 12. In the former case, the light emitted is highly coherent, thereby allowing the diffusing medium 14 to be separated by a long distance d from the gelatin film 16.

The nature of the diffusing medium 14 becomes less important when the diffusing medium 14 is separated by a long distance d from the gelatin film 16 since the divergence of the light exposing the film 16 is determined by the angle α . If a mercury

lamp is employed as the light source 12, spatial filtering through a pinhole can make the light suitably coherent. The use of mercury lamps would be desirable as they produce collimated light which is more uniform in intensity than that produced by the typical He—Cd laser. Furthermore, mercury lamps are less expensive and less bulky than laser light sources.

Thus, the method of the present invention results in a rear projection viewing screen of predetermined scattering characteristics, which screen scatters substantially uniform illumination over a relatively wide field of view about the normal to the screen.

It is to be seen that the above-described screen comprises a transparent substrate having a pair of opposing surfaces and a hardened gelating film on one of said surfaces of said substrate. A screen prepared according to the invention exhibits a scattering pattern of areas of different refracting index corresponding to the three-dimensional interference pattern recorded therein, such that the distribution of regions of constructive and destructive interference of the recorded certain interference pattern are distributed: (a) substantially randomly with respect to the plane of said screen and (b) in determined preferred orientations with respect to the normal to said screen. Consequently, the distribution of the recorded interference pattern predetermines the scattering characteristics of said screen.

WHAT WE CLAIM IS:—

1. A method of forming a rear projection viewing screen which provides in use substantial uniformity of illumination over a given field of view about the normal to the screen comprising: a) preparing a hardened gelatin film on a transparent substrate; then b) sensitizing the gelatin film to substantially coherent light; then c) exposing the gelatin film to substantially coherent light which has been transmitted through a diffusing medium; then d) developing said gelatin film to form therein a three-dimensional interference pattern composed of areas of different refractive index.

2. A method in accordance with Claim 1 wherein the light from the diffusing medium and falling upon the sensitized gelatin film subtends a maximum angle in the range of 15 to 40 degrees.

3. A rear projection viewing screen made in accordance with the method of Claim 1.

4. A method of making a viewing screen substantially as hereinbefore described with reference to the drawing.

5. A rear projection viewing screen made by the method of Claim 2 or 4.

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